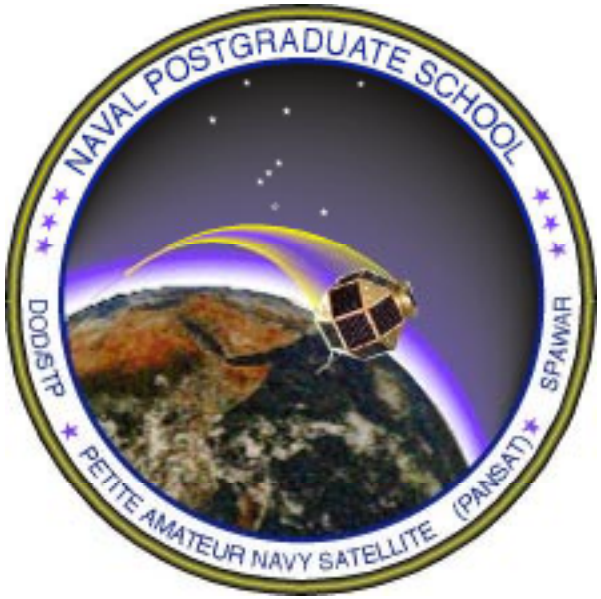
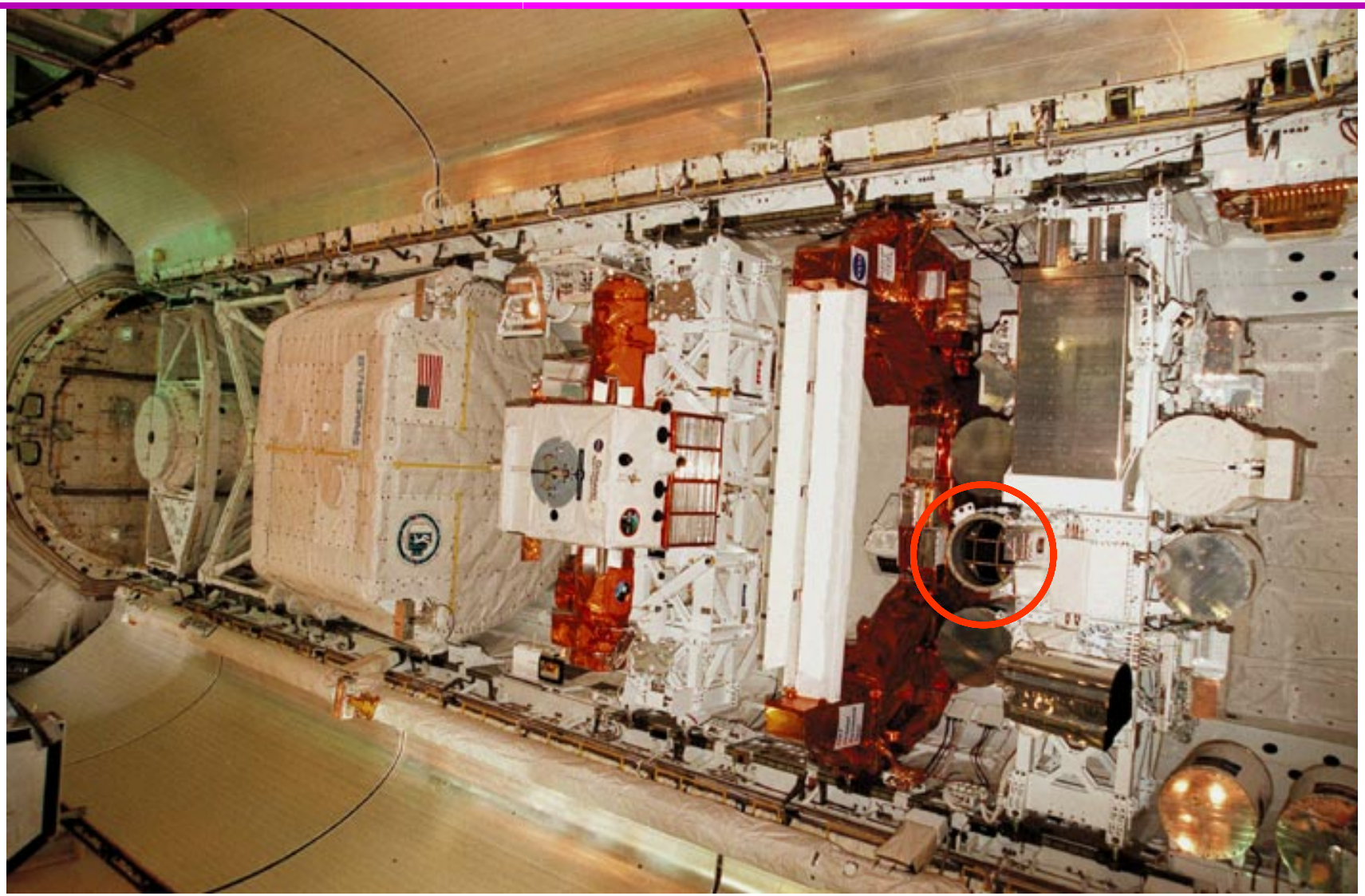
The Petite Amateur Navy Satellite (PANSAT) Hitchhiker Ejectable



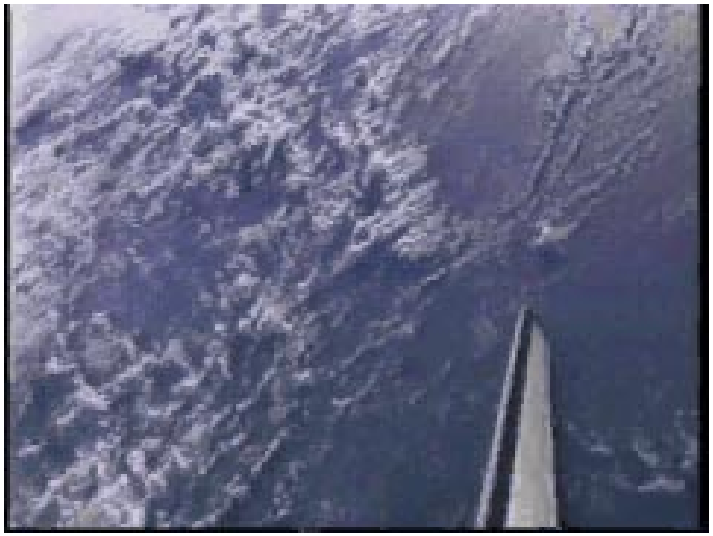
STS-95 Payload Bay



STS-95 Launch

23 hours, 26 minutes later . . .

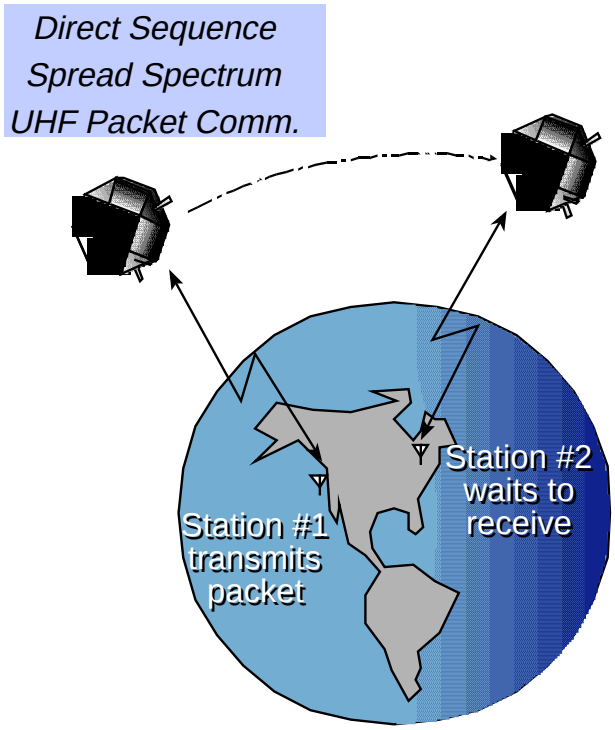
PANSAT Deployed



PANSAT Hitchhiker Ejectable

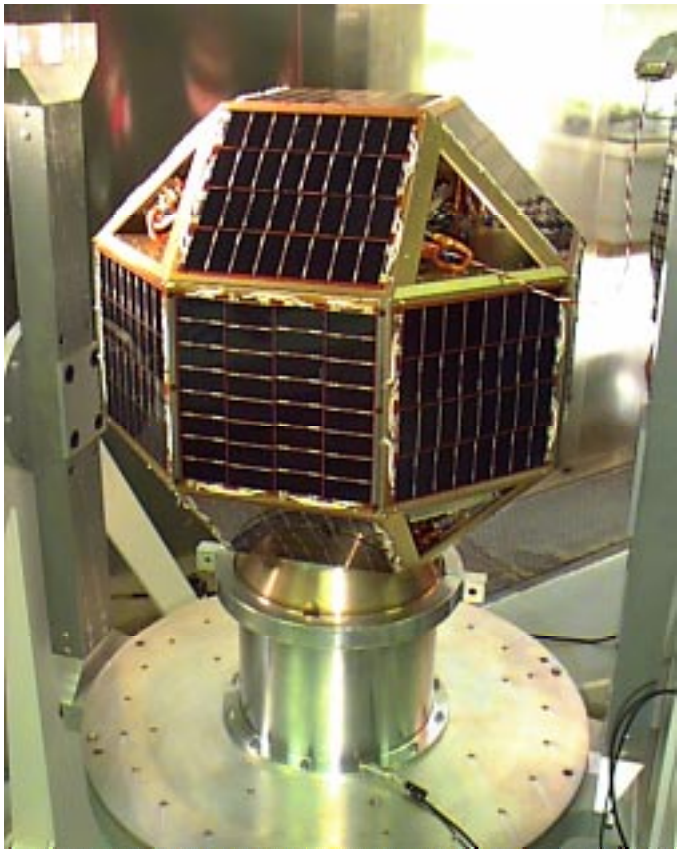
- Introduction
- Design Requirements and Issues
- PANSAT Testing
- Payload Safety
- Lessons Learned
- Conclusion

Introduction



- Hands-on space system development for officer students
- Global, digital message-relay
- Spread spectrum modulation
- Amateur radio involvement

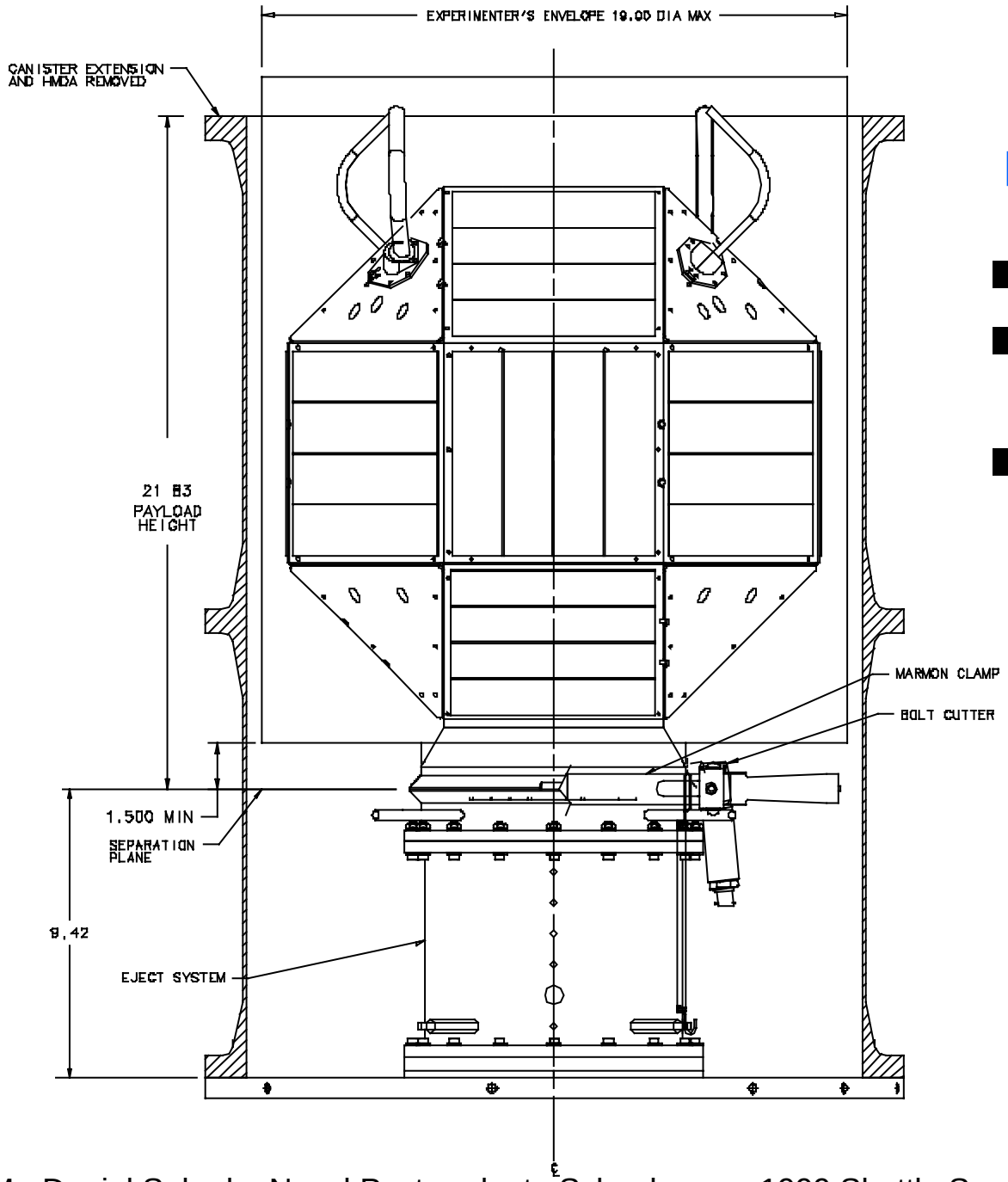
Introduction



- Designed and built at NPS
- 50 theses published
- Used in laboratory instruction at NPS
- Facilities installed to support spacecraft development
- Subsystem testing at NPS
- Integration and system-level testing at NASA/GSFC

Design Requirements

- Spacecraft Bus
  - Shuttle secondary payload as baseline
    - 150 lbs total weight (max.)
    - NASA Hitchhiker requirements
  - Simple Design
    - No propulsion
    - No attitude control
  - Development and testing at NPS
  - Communications with NPS ground station
  - 2-Year mission life



Payload Envelope

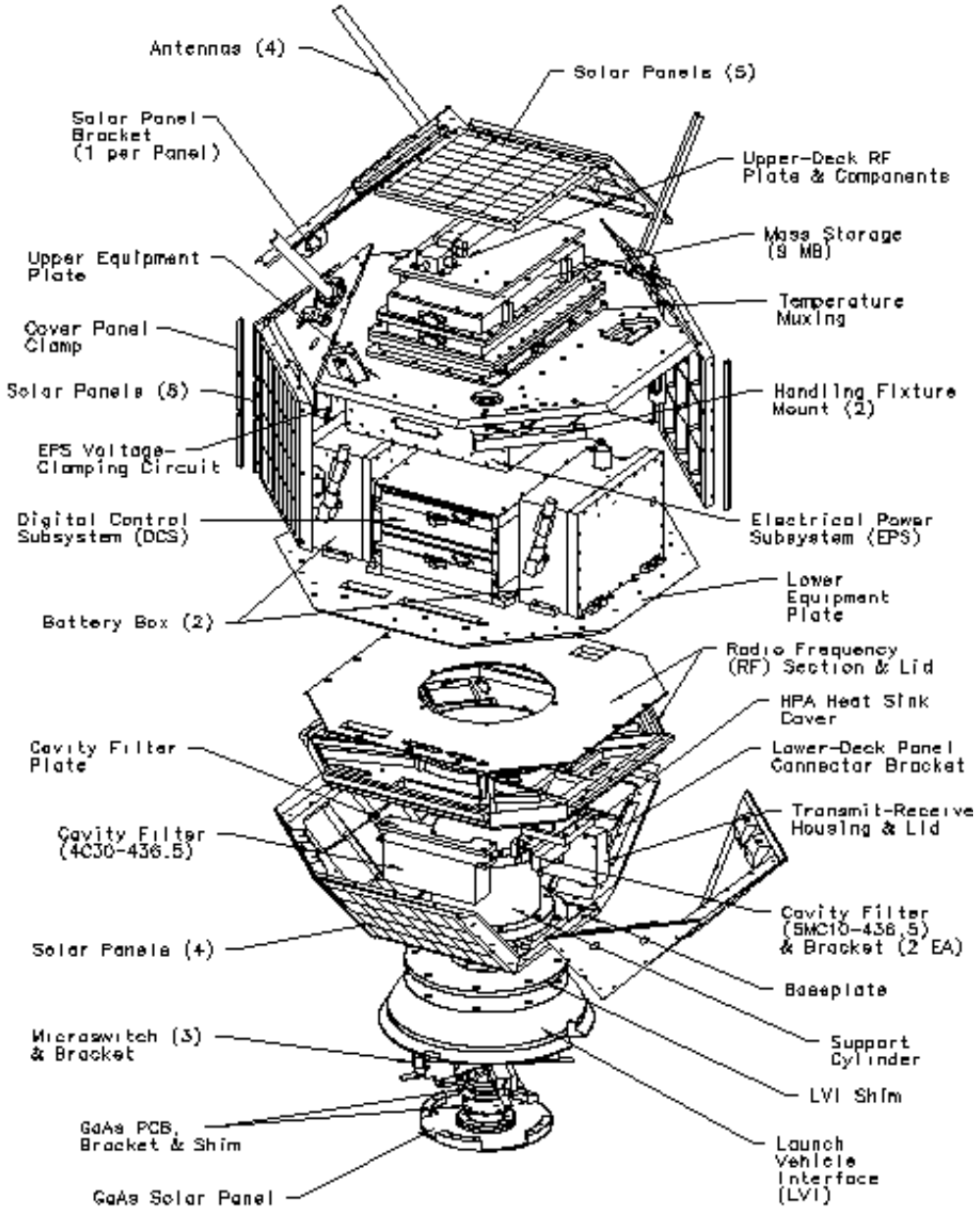
- 19-inch diam. (max.)
- 21.8-inch height (from separation plane)
- CG envelope: 1.27 cm (0.5-inch) radius from CL and 26.03 cm (10.25-inches) from separation plane

Hitchhiker Ejectable Requirements

- Design Limit Loads (analysis alone)
  - Factor-of-safety of 2.0 times limit loads for yield
  - Factor-of-safety of 2.6 times limit loads for ultimate failure

LOAD VECTORS FOR PAYLOAD VERIFIED BY ANALYSIS ALONE

Direction	Limit Load (g's)	Yield Load (g's)	Ultimate Load (g's)
± X, ±Y, ±Z	11.0	22.0	28.6
R_X, R_Y, R_Z	85	170	221

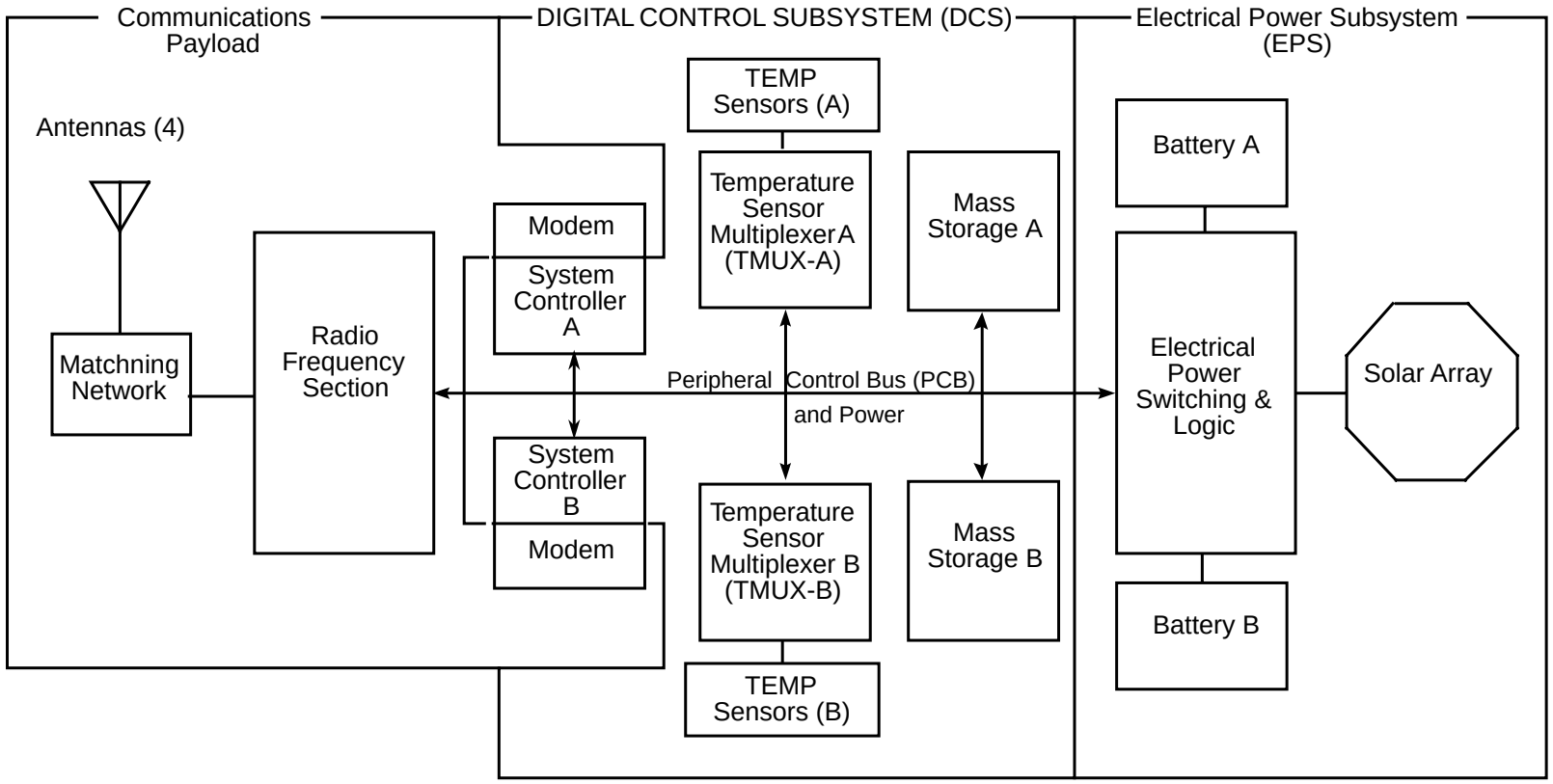


PANSAT

Expanded

View

PANSAT Block Diagram



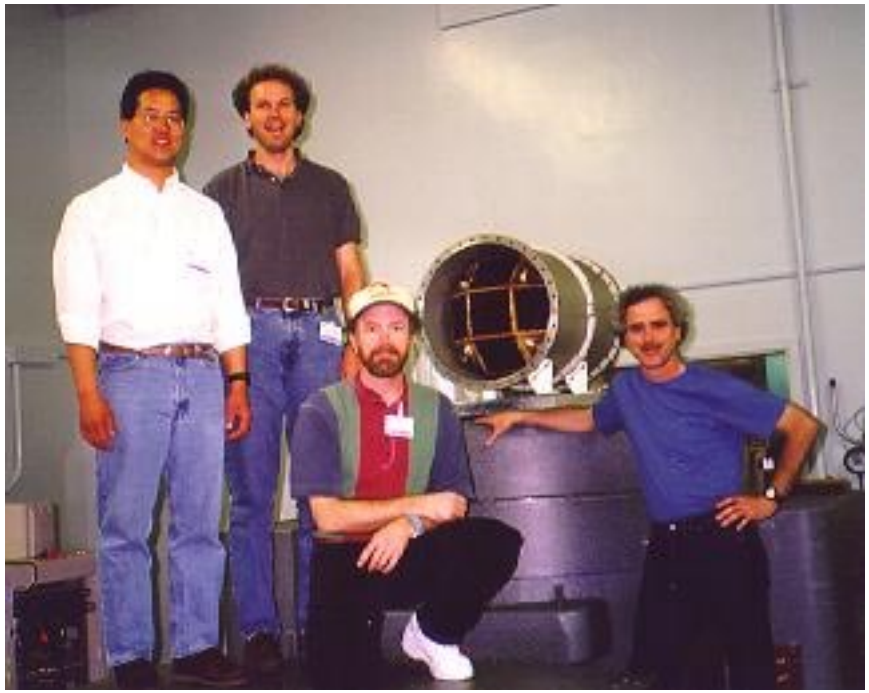
Spacecraft Design

- Subsystems
  - Communications payload
    - Modem
    - RF Section & Antennas
  - Digital control subsystem (DCS)
    - Processor board
    - Temperature multiplexer
    - Data storage modules (memory)
  - Electrical power subsystem (EPS)
  - Mechanical & Structure subsystem

Design Issues

- Hitchhiker Payload
  - Trade reliability for safety
    - Microswitches (3 single-points-of-failure in series)
    - RF timer circuit
  - Trade capability for safety
  - Ensure compatibility of materials
    - Low out-gassing materials
    - Fracture-resistant structural materials

PANSAT Testing



- Subsystem environmental test at NPS
  - Random vibration
  - Thermal-vacuum cycling
- System-level vibration at NASA/GSFC
  - Random vibe each axis
  - Vibration level: 8.2 g_{rms}
- Functional testing

PANSAT Testing

- Mass properties test
  - C.G. location determination
  - Within 1/16 inch of analytical
  - Moments of inertia on two axes

Payload Safety

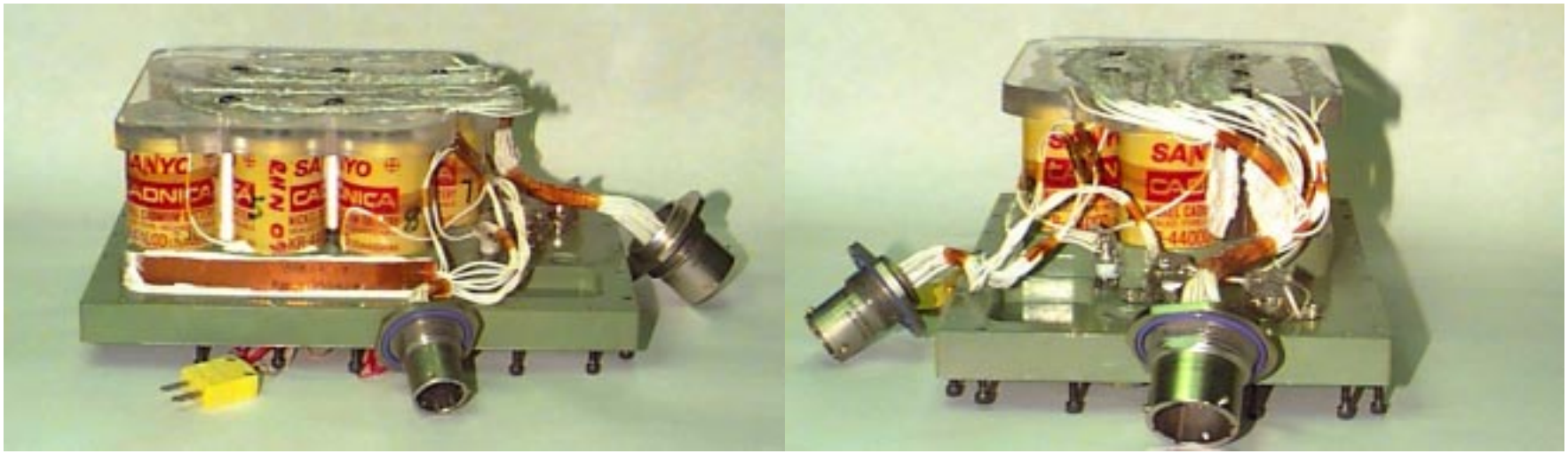
- Familiarize with Hitchhiker *Customer Accommodations and Requirements Specification* (CARS) and other documents
- Design to remove safety hazards
  - Removal of hazard
  - Inhibits (including payload operations)
- PANSAT safety issues
  - Batteries
  - Radio frequency (RF) emissions
  - Structure

PANSAT Battery

- Compliant with *Manned Space Vehicle Battery Safety Handbook, (NASA/JSC)*
- Battery construction
  - Teflon-coated interior of housing
  - Glass wool packing
  - Dry Nitrogen purge of housing
  - PRV in line with sub-micron filter
  - Thermal cutouts

PANSAT Battery

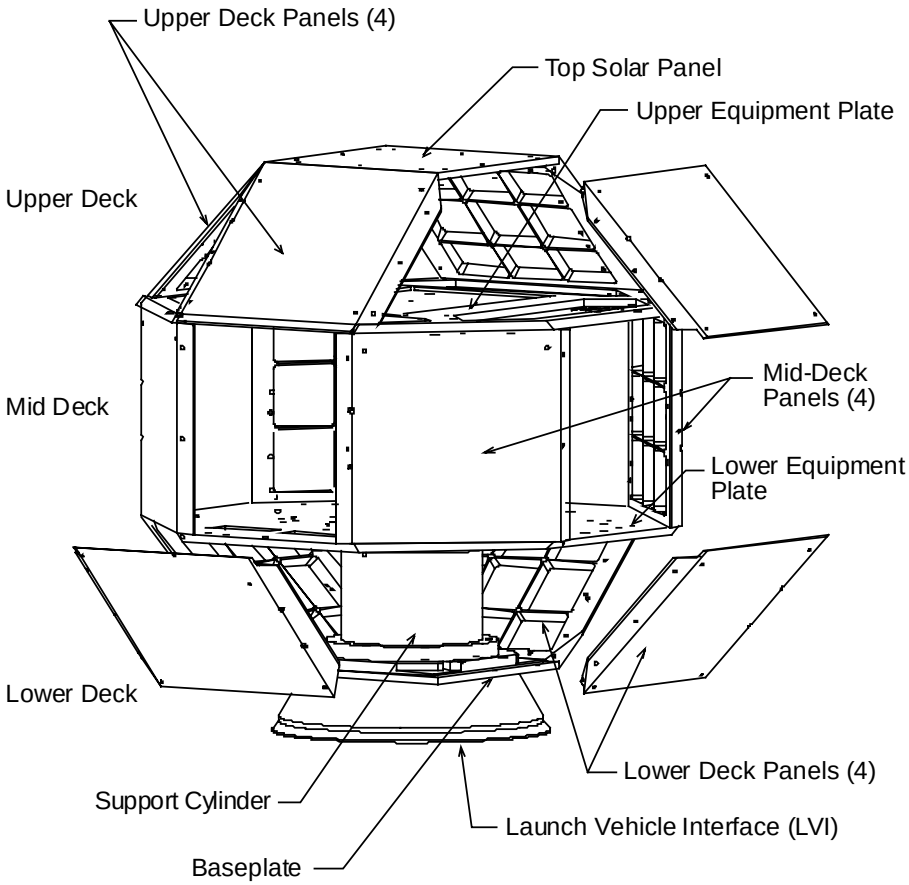
- Fully discharged at integration
- Microswitches inhibit charging - “dead in the can”



Safety Inhibits

- Microswitches applicable prior to ejection
  - Non-operational while in canister
  - (2) series-connected on power leg of solar panel power bus
  - (1) in-line on the ground leg of solar panel power bus
- 15-second timer added for post-separation
  - Inhibits transmission
  - Enabled after safe distance from orbiter

Structure Subsystem



Load-Bearing Structure

- Al-6061-T6
- Finite Element Analysis (FEA) verified through modal test
- High margins of safety
  - Structural strength
  - Low-risk classification for fracture
- Spacecraft weight not a problem

Lessons Learned

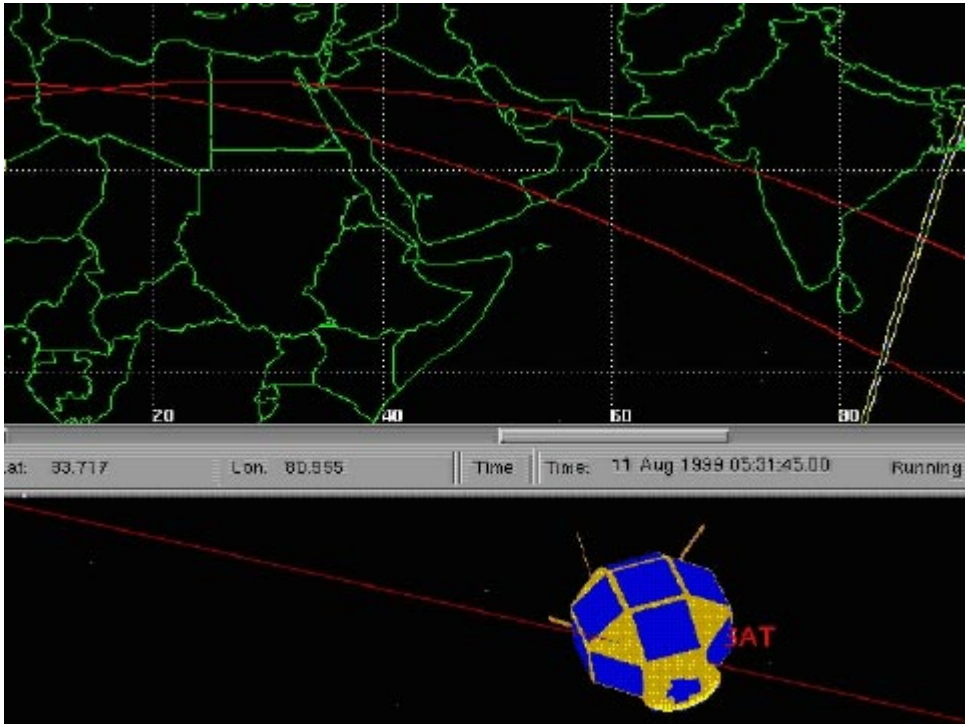
- Learn by doing: Hands-on experience invaluable in educational process
- Design with safety in mind
- Design to test: *see paper by J. Horning*
  - Recycle test setups
  - Recycle test procedures
- Emphasize rigorous testing at subsystem level

Satellite Performance

Satellite Performance

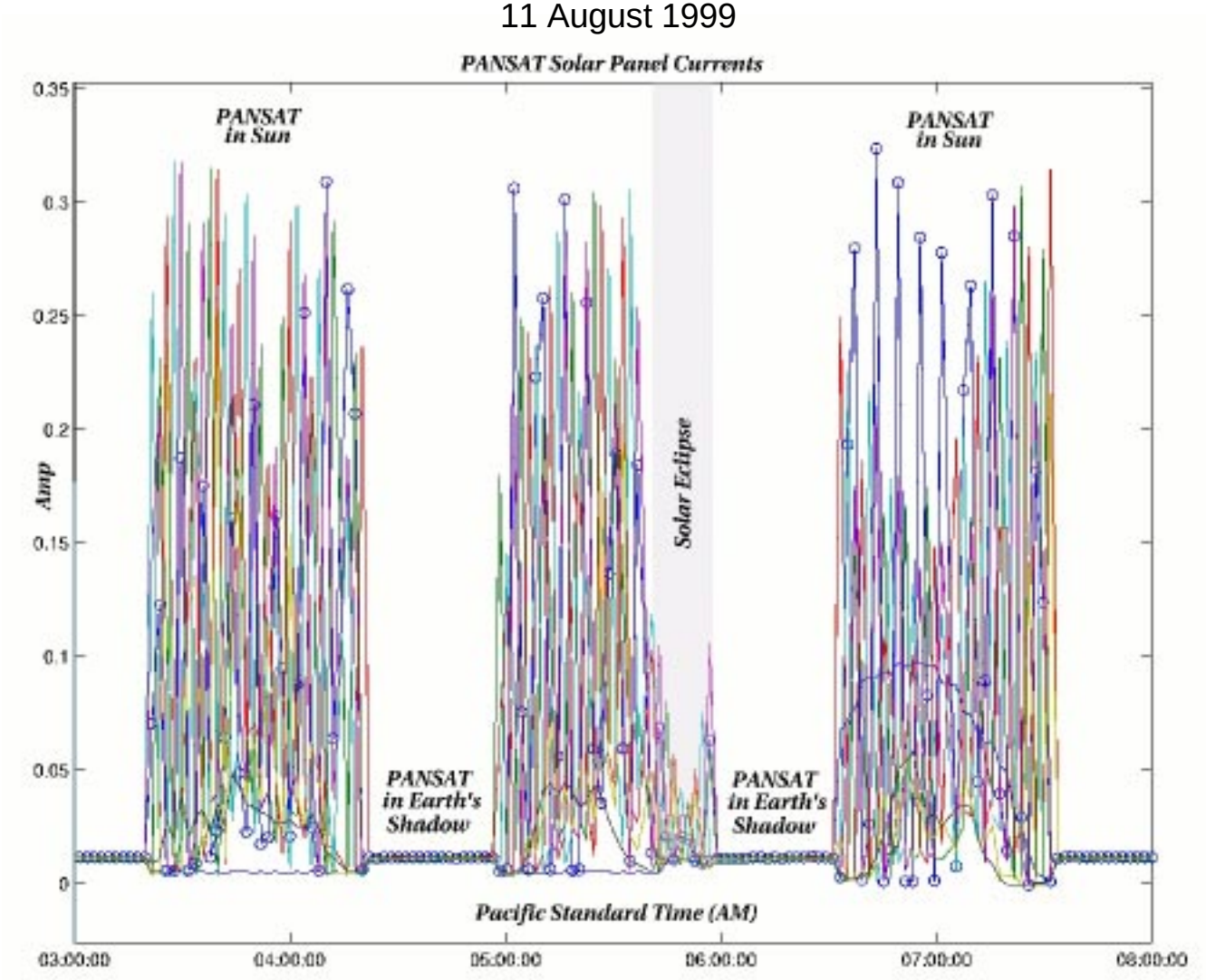
- Telemetry data
  - Solar panel currents (8)
  - Battery status (temperature, on-line, charge, etc.)
  - Spacecraft temperatures
- On-orbit operations
  - RF state reset
  - Telemetry processing
  - Determination of software updates

Aug. ‘99 Solar Eclipse



Aug. ‘99 Solar Eclipse

11 August 1999



For more information . . .

http://www.sp.nps.navy.mil/pansat